U.S. DEPARTMENT OF INTERIOR

The Banning fault has had a complex history that includes both left- and right-lateral displacements. During middle Miocene time the ancestral Banning fault zone may have generated left-lateral displacements that juxtaposed the

Open-File Report 92-354
The Re0.04cinity of the central Transv

fault has received much attention because it has played such an important role in the gological history of southern alifornia.

• Where, associated contractional and

family, and has led to variable fault nomenclature and to conflicting fault-movement scenarios.

FAULT NOMENCLATURE

The complex pattern of late Cenozoic right-lateral faults in southern California has led to nomenclature for the San Andreas fault that is more complex than for central

south branch is confusing: he indicates minor displacements on the south branch between San Gorgonio River and San Gorgonio Pass but large displacements on the same strand along the base of the San Bernardino Mountains (Dibblee, 1968a, p. 268), without elaborating on this discrepancy.

Our concept of basement terranes and their bounding faults in the southeastern San Bernardino Mountains borrows some elements from both Allen and Dibblee, but departs from both in the details of fault distribution and movement history. Our view of fault relations is closer to Allen's scheme than to Dibblee's. Despite the unifying appeal of Dibblee's nomenclature, his concept of north and south branches of the San Andreas fault is too simplified and partly is in err3.4as shown by later mapping (Ehlig, 1977; Farley, 1979; Matti and others, 1982a, 1983). Allen's (1957) interpretation of the Mill Creek and Mission Creek faults4as independent strands that follow separate routes through the San Bernardino Mountains more accurately delineates the boundaries of crystalline terranes native and exotic to the southeastern San Bernardino Mountains, even though Allen was unable to use the significance of these terranes to reconstruct a comprehensive movement history f3.4his fault strands. Although many workers have adopted Dibblee's nomenclature f3.4the San Andreas fault in the south-central Transverse Ranges, we recommend that this nomenclature be abandoned because it does not accurately reflect the geologic relations.

GEOLOGIC SETTING

Wilson Creek and Mission Creek faults

The Wilson Creek and Mission Creek faults are major strands of the San Andreas fault in the south-central

By this interpretation, high-angle faults now bounding the window have reactivated and modified a thrust surface (the Vincent-Orocopia-Chocolate thrust) that formerly had a low-angle geometry. Upper-plate rocks of this window constitute rocks of the Wilson Creek block that appear to be unlike those native to the San Berna 18.n,Mountains or those in the upper-plate of the Vincent-Orocopia thrust to the south.

absorbed by convergence within the Cucamonga fault zone and uplift of the southeastern San Gabriel Mountains (Matti and others, 1982b, 1985; Morton and Matti, 1987; Morton and

vicinity of Whitewater canyon southeastward to the southern Indio Hills, where it merges with the San Andreas fault. The trace of the segment is well defined by conspicuous linear vegetation traces (Allen, 1957, fig. 1 of pl. 6) and forms degraded scarps in alluvial units that are late Pleistocene and Holocene in age. No published studies address the Quaternary history of this segment of the fault.

Geologic history

Late Cenozoic right-lateral history.--Evidence for at least 16 to 25 km of late Cenozoic right slip on the Banning fault is provid034 Tc0.4(geologic relations among T)121.2(e)-0.1(rtiary)]TJT0.004 Tc0.0782 Tw[(sediment)15.2(ary)10.7(rocks because the two sequences are not exact cross-fault counterparts: they differ in details of their physical stratigraphy and in their relations with underlying rocks.

Moreov, their benthic foraminiferal assemblages suggest different paleogeographic settings for the two sequences (K.

data), and they have similar major and minor element compositions (Baird and others, 1974, 1979).

(2) The mylonitic belt of ductile deformation that separates foliated granitoid rocks from highly deformed retrograded granulities in the San Gabriel Mountains is similar to the Eastern Peninsular Ranges mylonite zone of Sharp (1979), except that mylonitic lineations are oriented down-oils in most parts of the Eastern Peninsular Pengage mylonite. in most parts of the Eastern Peninsular Ranges mylonite

Campbell and Yerkes (1976), and Truex (1976) presented evidence for 60 to 90 km of left slip on the Malibu Coast-Santa Monica-Raymond trend during the middle Miocene (about 16 Ma to 13 Ma) price and a of leaft?

(about 16 Ma to 12 Ma)cmise onat a of le4tt3(ast-)]TJT0.0037 Tc0.5132 Twlateral fault km this0 0aiddmust be km regional) uex

Bernardino strand by reactivation of the abandoned Mission Creek strand starting in late Pleistocene time (discussed above).

Cucamonga fault zone.--The Cucamonga fault zone at Day Canyon in the east-central part of the zone has a minimum convergence rate of about 5 mm/year for the last 13,000 years (J.C. Matti, D.M. Morton, J.C. Tinsley, and L.D. McFadden, unpubl. data). Age control for this determination is based on correlation of pedogenic soils that cap faulted

We start with the premise that right-slip occurs on the San Andreas fault in the Coachella Valley but does not carry through the San Bernardino Mountains. We assume that about 25 mm of annual slip occurs on the Coachella Valley segment of the San Andreas between the Salton Sea and the northern Coachella Valley; this figure is consistent with a range of slip values indicated by geologic and geodetic data (Keller and others, 1982; Savage and others, 1979; Savage, 1983). Modern neotectonic slip accounts for the youthful tectonic geomorphology displayed by the San Andreas fault along this segment (Keller and others, 1982; Clark, 1984). However, northwest of Desert Hot Springs, the Coachella Valley segment loses its fresh tectonic geomorphology and our preliminary data suggest that late Quaternary alluvial units significantly by the fault. Farther northwest, the Wilson Creek, Mission Creek, and Mill Creek strands of the San Bernardino Mountains segment are paleotectonic faults that have been abandoned as throughgoing right-lateral strands of the San Andreas fault. Thus, we conclude that during late Quaternary time, fault in the northern Coachella Valley has stepped left onto the Banning fault. This process may account for two features. (1) As slip has been transferred across the gap between the two faults, the youthful Indio Hills have been squeezed into an anticlinal uplift. Thus, some percentage of right-slip on the San Andreas would be converted into compressional strain. (2) A left step between the San

not been displaced

most if

u

Helen fault, which has scarps and sag ponds in the Devore area, and thence to the San Bernardino strand--thereby creating an extensional strain field that giverise to normal dip-slip displacements on the Peters and Tokay Hill faults. A right step from the San Jacinto to the Glen Helen may explain a distinctive seismicity lineament between the inferred traces of the two faults beneath the floodplainndof Cajon and Lytle Creeks (Green, 1983, fig. 7). Extension created by adregional right step from the San Jacinto to the San Andreas fault may occur throughout the San Bernardino Valley region, and may create high heat flow that accounts fordhot springs and subsurface hot-water zones that occur at several locations in the valley region.

Right-stepping transfer of slip and (or) accumulated strain from the San Jacinto to the San Andreas would create a right-lateral shear couple that could generate clockwise block rotations of the type proposed by Nicholson and others (1986). During the period between large earthquakes on either the San Jacinto ordSan Andreas faults (the interseismic period of Nicholson and others, 1986), accumulated shear strain within the San Bernardino valley region partly could be released by block rotations and extensional faulting; large earthquake events on the San Andreas and San Jacinto faults would release strain accumulated along the marginndof

an integrated regional response to an evolving left step in the San Andreas fault.

Acknowledgeme7ts

This report is a revised version of U.O. Geological

California: Pacific Section, Society of Economic Paleontologists and Mineralogists, Field trip guide

Arthur, eds., Proceedings of conference on geologic problems of San Andreas fault system: Stanford University Publications in Geological Sciences, v. XI, p. 294-305.

- ----1973, History, seismicity, and engineering geology of the San Gabriel fault, in Moran, D.E., Slosson, J.E., Stone, R.O., and Yelverton, C.A., eds., Geology, seismicity, and environmentact: Association of Engineering Geologists Special Publication, p. 247-251.
- ----1975, Basement rocks of the San Gabriel Mountains south of the San Andreas fault, southern California,

 $\mbox{U.S. DEPE[(UhT)-5.7(M)7.5(E(P)-9.NT)-5.7(OF)-5.7(I(.)-10.N)1-9.T DE. } \\$

----1981, A review of geological evidence for recurrence